AERIAL SURVEYING

By Walter H. Schotts, '27

ONWARD speeds time like the Golden State Limited, waiting for no man or thought, the alert and thoughtful always developing and projecting new ideas before the public. It is this class of people who has given us the high type of civilization which we now possess. This development is collective in one sense that the man who develops realizes and attains the better and cheaper methods of production, passes it on to the next man so that he may be benefited by it. Hence it is natural that aerial photography should develop in like manner to other achievements. Time was, not so long ago, when engineers viewed a map made from aerial photographs with skepticism; when surveyors regarded it as a form of competition to be feared; and the man higher up thought of it only in the terms of an interesting novelty, useless perhaps, but not to be rated in the same class as engineers' maps. Sentiment has changed and today finds surveyors, engineers and executives making extensive use of aerial maps for a variety of purposes. It is worthy of note that the Topographic Branch of the U. S. Geological Survey, a body that contains some of the world's greatest experts in map making is now giving preference to aerial photographs, their experience having proved that better maps can be obtained at a materially reduced cost and time.

Before man flew, he was able to see and produce on a sensitized plate any event or sight which was his wish to record. Now with the combined resources of the airplane and the camera, he is able to put surveying at the head of engineering accomplishments and now is eabled to see actually as a bird sees. Surveying is changed from the basis of a snail to that of the eagle. Is there any comparison?

It is said that on the walls of caverns in France, alongside crude scratches resembling animals, are what are termed very crude but distinguishable maps which from their character are of the caverns themselves. The art of map-making is apparently so old that it is not at all doubtful if Noah did not use a map to find his bearings after the flood. In 1492, maps indicated that little was known of much of the world other than that around the Mediterranean. It was thought that outside of the Rock of Gibralter, you would suddenly drop off the earth into an unknown abyss. By comparison, the great advancement of this division of science is not doubted.

George Washington used the chain for the crude surveying he did for Lord Fairfax. He was gone days into the lonely wastes of the wilderness and it is true that this survey was far from accurate, as the instruments of the time did not lead to accuracy. Surveying advanced rapidly and until a few years ago, we thought that we were as accurate as possible. Now the ground surveying has been supplemented in part by photographs taken from the air.

War, declared in 1914, brought into play all the ingenuity and crafts of men. A remarkable achievement was the airplane. It was used from the first to make observations on enemies' activities. Soon commanders demanded a more complete description of the terraine and actions of the enemy. To this end ingenious minds were put to work. Their product, the aerial camera is now used in many ways in commerce.

In the last six years aerial photography has passed from a very mediocre stage in the onrush of industry to one of the most important aids in commercial development. This new art has left the experimental stage far behind and with the inventing of new aerial cameras, engineering achievements have been speeded greatly.

There is not a person who has not at some time or other glanced at a newspaper to find a large number of views of a catastrophe, a celebration or great public event, all taken from an airplane. What method is better to give you the impression that you are being asked to grasp and again why can it not be made to survey land since it is much quicker? A brief general review of the varieties of use of this instrument of industry will bring home to you its good points.

Petroleum Companies and Their Geologists. Aerial mapping of territory has not been used a great deal until the present time by geologists. The main reason being that no practical means by which it could be readily adapted to the geologist's mind had been discovered. They now have this method on a very practical basis with corporations equipped to serve the populace at a very short notice. Petroleum companies have found aerial photography beneficial in the exploitation period. In this manner by making maps to a large scale, the terraine can be studied over the entire holdings, which may be thousands of acres. Before, the surveyor would have to spend days just looking over a small tract of the companies' land. This meant a great reduction from the best results as the best property may not have been viewed. One large map will enable the geologist to judge where he should improvise roads for bringing materials and supplies to the drilling stations, and the best methods of drainage and thus a large number of the side trips are avoided. Possibly the drilling is to be started in a region that has never been surveyed successfully. Under these conditions disputes as to possession may arise. The solution is the aerial photograph which gives at a glance the main features of the terraine as they exist. Should they get production, the problem of laying pipelines would be simplified a great deal. The preliminary laying of these lines can be done directly from the aerial maps. In other words, time, a main factor of life is saved with greater accuracy encountered than could have been possible without a complete map.

Locating High-tension Power Transmission Lines. Companies employed in the above occupation were the first to grasp the opportunities and advantages offered by the aerial map. To date about 25 power and electric companies throughout the United States and Canada have used aerial photographs. In a very short time aerial maps can be made over the wide section of territory necessary and under such circumstance that the suspicion of the farmers is cast aside. A large number of right-of-way condemnations are

avoided and the deals are closed in shorter time with a great saving of money. Better alignment, the one factor which is very important in transmission line work is made possible by the ability to view features of the terraine exactly as they exist, thus avoiding many obstacles and causing less interference with private interests than at any time heretofore. The material saving of time looms up as the largest advantage since the slowness of ground surveying is very apparent. Now complete maps are assembled to scale in a small fraction of the time in which ground surveying could be accomplished. Time and money saved are thus placed first among the advantageous features. The aerial cost to the Pennsylvania Water and Power Company for lines of approximately 100 miles in length was but $50 per mile.

Harbor Surveys. For any large body of water, a direct vertical view gives to you the water line and size of boats and barges used and to this end calculations are reduced. It is therefore to make harbors safer and enables the placing of proper entrance routes along with the required size docks to take care of all traffic which has its approach by land or water.

Reservoir Surveys. (Including domestic and water power.) In the study of proposed sites for a reservoir, it is necessary and essential to base your proceedings on a contour map. In this way, aerial maps can aid, in that of a photograph to the scale of 800 to 1250 feet to the inch, contour points are plain enough so that they can be traced directly. Various companies and municipalities throughout the United States have availed themselves of this relatively easy method.

Traffic Studies. During these days of ever increasing automobiles, we can use aerial photographs for all eliminating congestion in the business portion of cities. A good example of this is the map made by the Automobile Club of Southern California of the heart of Los Angeles. It was not large in size and the scale was 200 feet to the inch. They used it in determining new street widths and for other forms of traffic relief.

Tax Assessment. At this time when "Tax Reform" is resounding throughout our brave land, we demand proper tax assessment, and for the justice demanded we must have an assessor. The first question put to you by this safeguarder of equality is for maps. If the required maps are not to be had, what are you to do? It would take a long time for a ground survey and an exhorbitant price. No small municipality could stand it. The solution would be the aerial map which is relatively cheap and very speedy. The saving is approximately ten-elevenths in price and about nineteen-twentieths in time. Besides, the photographic map gives information for tax assessing purposes that is invaluable and that cannot be procured by any other method.

Park and Landscape Gardening. Just where shall shrubs and trees be placed? From the ordinary views taken while on the ground, you cannot gain that invincible privilege of gaining perfect symmetrical arrangement which you can gain from the airplane. You can thus arrange your ideas on the photographed map in coordination with all existing features which go to make a sound and beautiful landscape. The work is thus diminished to a minimum with better results.

Flood Control. The Colorado River delta, covering some 325 square miles of waste land, subject to shifting channel conditions and overflow by floods was mapped from the air for the purpose of planning levees for the protection of the irrigated lands in the Imperial Valley nearby. This map at 1000 feet to the inch, affords a fine example of the value of aerial surveying in a region where ordinary surveying cannot be carried out except at great expense and hardship.

Timber Surveys. In Canada extensive aerial surveys have been in progress in the last few years which cover many miles of territory. They supersede the old time timber cruising which was necessary in order to get the stumpage value of a forest. By caliphers used on an aerial map and by comparison with a sample, the stumpage can be estimated. Also, the aerial pictures have been found of assistance in planning logging railroads, sawmill and camp locations.

In all, the uses of the aerial photograph are not concluded with the above descriptions. They may be of use in laying out railroads, fighting wars, in making geologic quadrangles and last, but not least, for advertising. Many noted advertisers have used the form of illustration known as a birds-eye view. Effective illustration is a vitally important factor in successful advertising. They may be employed merely for attention attraction, it is true, but the primary reason for their use is to place before prospective customers a true and interesting representation of the thing advertised. Hence for the advertising of real estate, roofing, automobiles or amusement parks, they are invaluable.

There are four distinct products of aerial photography: (1) The oblique photograph taken at a moderate altitude and at an angle to the vertical with a single lenses camera to gain what is known as a birds-eye view. (2) The mosaic map is an assembly of a number of adjoining single lenses ward. Due to slight variations in scale they cannot be matched up conclusively and are good only for general reference. It is no longer as popular as it was a few years ago and is rapidly being superceded by the following more accurate form. (3) Photographic map is a high form of mosaic map in which every care is taken to bring adjoining photographs to the same scale. Various forms of control are also used to orient the photographs to their correct relative positions. This form is now used a great deal. (4) Line maps are hand drawn maps. They are the contours of a photographic map transferred to a transfer cloth by direct tracing. Their use is very effective when a topographic map is necessary.

Scale Map. The selection of the proper scale is of paramount importance, first, that the map may serve the purpose for which it was intended; second, the scale affects the cost of the map more than does any other element. A large scale map, that is, one that shows objects in large size, requires a large amount of exposures, excessive labor and adds to the technical difficulties of assembling the map. Small scale maps lessen the difficulties referred to, in proportion to their scale. These photographs, if sharp and clear can be enlarged within a certain range but this does not diffuse all of the difficulties of large scale. On

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contact prints, those developed from a negative made to a scale of 800 feet equals an inch cover an area of 1.5 square miles. The film measures 7 by 9⅛ inches.

Overlap. The customary way is to make the exposures overlapping on each other, by flying the airplane methodically in parallel back and forth in so-called strips, continuing this process until the area is covered. The widest dimension of the camera presents the width of a strip. Experience has taught the aerial photographer the wisdom of allowing a generous overlap. This is accomplished by having successive exposures overlap on each other by about 50% and the successive strips overlap each other by about 60%. The former is spoken of as end lap and the latter as side lap. This would theoretically give a net area to each exposure of only about .2 of the area of one ex posure. In actual practice this is very seldom realized due to the difficulty experienced in flying between perfectly straight lines. The necessity of a generous overlap will become apparent for the following reasons: (1) It is only the objects immediately in the center that are seen exactly vertical. The objects to the outside of each photograph are at an angle and if the camera is slightly tipped they are distorted. (2) In order that a large number of photographs may be assembled, it is necessary to see the relation of the objects in the center to all other points. (3) Sufficient overlap makes possible the elimination of occasional defective exposures due to one cause or another. (4) For viewing objects stereoscopically, a certain amount of overlap is necessary. In order that any portion of an aerial photograph may be studied in the stereoscope a 50% overlap is an absolute necessity. (5) The side lap is pri-

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marily essential in order to insure continuity between adjacent strips and affords a safety margin for such irregularities as occur in flight. (6) An incidental factor that arises from the use of overlap is the ability to see obscure objects from more than one angle, and this is especially valuable when using the stereoscope.

Ground Control. Ground control is as essential to aerial surveying as to ordinary surveying. However it is obvious that the control points must be much larger in order to be seen readily from the plane, or they may be large hills or prominent rocks. Sometimes it is desirable to mark the more important control points with white cloth or dry powdered lime in the shape of circles or crosses large enough to show plainly on the photograph. More often the natural control points such as fences or road crossings are best.

Camera. The standard cameras used in the United States are of special construction and are made with lenses of 8-inch, 10-inch, 12-inch, and 20-inch focal lengths. The film is 9¼ inches wide and 75 feet long, capable of taking over one hundred exposures 7 by 9 inches. In the Eastman camera the film is sucked by partial vacuum against the back of the film holder, and in the Fairchild camera the film is pressed flat against a flat plate at the instant of exposure to prevent bulging or warping of the film. In the Bagley camera the film is gripped in a frame which accomplishes the same object. The lenses are so ground as to produce images practically free from distortion. A gimbal joint support and a spirit level make it possible to maintain accurate vertical position of the camera.

Stereoscope. The word stereoscope has been used several times throughout this article. To be definite, human vision is stereoscopic; it is that element of sight by which a third or depth dimension is given to the objects we see. Everyone is probably familiar with the old fashioned parlor stereoscope and the effect is very similar to the one employed in aerial photography. The effect is gained in aerial photography by letting the photographs overlap 50% or better and this is then viewed through a stereoscope. The stereoscope gives you a natural picture and by its aid heighths of objects and depths of depressions are calculated. They are very valuable for this reason to almost every branch of engineering.

Time Required. The time required to photograph a definite area depends wholly on weather conditions. A clear day and very little wind is essential. The clearness to make the photograph visible and the little wind to enable the aviator to keep a relatively straight course. It is possible to photograph from 60 to 80 square miles in one day, but under average weather conditions it takes 30 days to complete 100 square miles at a scale of from 800 to 7000 feet per inch.

Generally speaking there is nothing cheap about an aerial photographic surveying, and many engineers have been greatly disappointed by its cost. It is a fact, nevertheless, that aerial surveys are cheaper than ground surveys, and that they make available more information for the amount of money expended than is possible by any other method.